ELSINORE VALLEY MUNICIPAL WATER DISTRICT
PILOT PROJECT OF TERTIARY TREATED WASTEWATER DISCHARGE INTO LAKE ELSINORE

PROPOSED MONITORING PROGRAM

April 2, 2002

Introduction

Lake Elsinore lies 60 miles southeast of Los Angeles and 22 miles southwest of the City of Riverside. The Lake is located within the City of Lake Elsinore in Riverside County, and is a natural low point of the San Jacinto River and its drainage basin. The total drainage basin of the San Jacinto River watershed is approximately 782 square miles. Over 90 percent of the watershed (735 square miles) drains first into Railroad Canyon Reservoir (Canyon Lake), and then flows into Lake Elsinore, the terminus of the San Jacinto River watershed. The local tributary area to Lake Elsinore, consisting of drainage from the Santa Ana Mountains to the west and the City of Lake Elsinore, is approximately 47 square miles.

Lake Elsinore is a relatively shallow lake with a large surface area. At the current lake outlet sill elevation of 1,255 feet, the lake has an average depth of 24.7 feet and a surface area of 3500 acres. Annual average precipitation in the Lake Elsinore watershed is approximately 11.6 inches; average annual evaporative loss is 56.2 inches (Montgomery - Watson, 1997). This excessive evaporation loss compared to natural inflow results in very low lake levels; at the extreme, Lake Elsinore was completely dry in the 1950s and 1960s and possible more in geological times. Therefore, Lake Elsinore is also called an ephemeral lake. Only in extremely wet years does Lake Elsinore overflow into Temescal Creek. In the last century, Lake Elsinore only overflowed five times (1919, 1981, 1983, 1993, and 1995), causing extensive flooding in the City of Lake Elsinore.

To prevent the Lake from drying out and also to mitigate the flooding potential, the US Bureau of Reclamation (BOR), the U.S. Army Corps of Engineers and the County of Riverside Flood Control and Water Conservation District developed the Lake Elsinore Management Project (LEMP). Three major projects were implemented through the LEMP: 1) construction of a levee to separate the main Lake from the back basin to reduce the Lake surface area and thereby prevent significant evaporative losses; 2) realignment of the Lake inlet channel to bring natural runoff from the San Jacinto River; and, 3) lowering of the Lake outlet channel to increase outflow to Temescal Creek when the Lake level exceeds an elevation of 1,255 feet. The LEMP also called for the introduction of supplemental makeup water to maintain Lake levels at an operation range of 1,240 to 1,247 feet. However, the source of the supplemental makeup water has remained elusive.

Lake Elsinore has been plagued by water quality problems such as algal blooms and fish kills. The excessive nutrient input to Lake Elsinore has cause the algal bloom and accumulation of organic material in the lake. The decomposition of the organic debris consumes oxygen in water column and has caused many instances of fish kills. Regional Board has listed Lake Elsinore as impaired due the excessive nutrients, low DO, siltation and unknown toxicity. The stakeholders in the watershed have been involved in the development of Total maximum Daily Load (TMDL) for these identified nutrients to improve the water quality of Lake Elsinore. It has also come to light that water quality is closely related to water supply of Lake Elsinore. Currently Elsinore Valley Municipal Water District (EVMWD) is proposing to release the tertiary treated wastewater as a pilot project to explore if recycled water, at the proposed volume and nutrient levels, can be a viable source of the supplemental makeup water for Lake Elsinore.

Objectives

The objective of the monitoring program proposed herein is to determine the impact of recycled water addition on lake water quality, especially on nutrient levels, algal biomass and dissolved oxygen. The monitoring program will specifically:

1. Quantify changes in water quality within the delivery channel (including any nutrient removal and diel and seasonal variations in DO and temperature).

2. Evaluate the local effects of recycled water discharge on water quality near the influent channel, including nutrient concentrations, as well as mixing, dispersion and plume dynamics.

3. Determine the lake-wide response to recycled water addition (nutrient concentrations, chlorophyll and DO concentrations, transparency and other water quality parameters).

The results of the monitoring program will be used to determine the nutrient assimilative capacity of the lake and provide a direct index of local, short-term and lake-wide, long-term response to known levels of external loading. The results can also be used to verify the BATHTUB-predicted mean annual water quality in the lake following recycled water inputs (Anderson, 2001).

Duration

The proposed pilot project for recycled water inputs to the lake is 2 years in duration, so the corresponding monitoring program is also 2 years in length. Monitoring will begin prior to the flow of reclaimed water into the lake and will continue for 1 month after termination of the reclaimed water flows into the lake.

Progress Meetings

Monthly progress meetings will be held at one of the involved agencies offices for the first 3 months, then bimonthly after that. The purpose of these meetings will be to evaluate the results of the monitoring program.

Proposed Sampling Locations

A total of 11 lake sampling locations (Fig. 1) and 4 channel sites are proposed. The three sites in red represent the regular sampling stations for the TMDL monitoring program conducted by the RWQCB and will continue to be used in this program, allowing comparison with the 2001-2002 sampling results and development of a long-term record of water quality at these sites. The 8 sites shown in black will be used to quantify local water quality changes near the discharge point for the recycled water. These sites were chosen based upon 2-D depth-averaged finite element simulations that suggest that the plume (defined here as SRP concentrations >20 µg/L) will be restricted to less than about 1000 m from the discharge point and will generally follow the shore (Appendix).

In addition to these 11 sampling stations on the lake, 3 additional sites in the recycled water delivery channel will also be regularly monitored (not shown). Sites at the discharge point of the treatment plant, halfway between the treatment plant and lake, and just above the confluence with the lake will be sampled and analyzed as described below.

All sampling locations will be located and referenced using GPS (WGS-84) and marked with surface buoys or (for the channel sites) stakes.

Field and Lab Parameters

In situ measurements of water quality will be made at each of the lake sampling stations at 1-m depth intervals using Hydrolab and Turner Designs water quality probes. Parameters measured will include:

- temperature
- DO
- pH
- EC
- turbidity
- chlorophyll
- Secchi depth

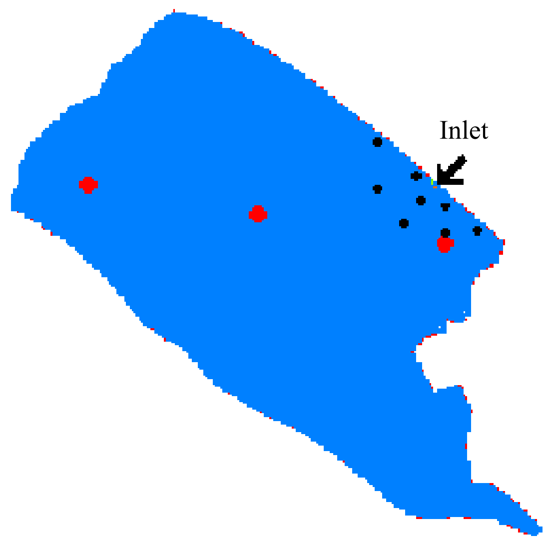

Fig. 1. Proposed lake sampling locations.

Water samples will be collected at the surface, 3 m and 6 m depths where possible. In water greater than 2 m depth, at least 2 depths (surface and bottom) will be sampled. Samples will be stored on ice and returned to the lab for total N and total P and dissolved NO_3-N, NH_4-N, and SRP following Standard Methods (APHA, 1989). Chlorophyll will also be measured on selected samples extracted in acetone using fluorescence spectroscopy (APHA, 1989b). Chlorophyll a concentrations measured using acetone extraction will be used to correct for any turbidity interferences from *in vivo* fluorescence estimates of chlorophyll using the Turner Designs fluorometer probe.

In conjunction with the above water quality parameters, a dissolved metals analysis will be conducted at least once a year. For this analysis, water samples will be filtered through 0.45 µm polycarbonate filters and acidified with trace metals-grade HNO_3. The samples will then be analyzed with ICP-OES and/or ICP-MS. An initial metals sampling and analysis will be conducted prior to the addition of recycled water.

Sampling Schedule

An intensive monitoring program is proposed for the two weeks prior to and four weeks following start of recycled water addition (Table 1) Field measurements will be made every M, W, and F for the first 6 weeks, with samples collected for dissolved and total nutrient analyses every W. Following this intensive monitoring period, field measurements and water sampling will be conducted every W through the end of the summer and then biweekly through the end of the project period.

Table 1. Proposed monitoring schedule. (X=Hydrolab casts only, X*=Hydrolab+nutrients).

Schedule	Week	Monday	Tuesday	Wednesday	Thursday	Friday
A	1, 2 (prior to RW)	X		X*		X
A	3-6 (following RW)	X		X*		X
B	7-25			X*		
C	26 – 100			biweekly*		

**water samples will be collected and returned to the lab for total and dissolved nutrient analyses*

NOTE: In addition to this regularly scheduled sampling, additional testing will be conducted following schedule A when the mean chlorophyll concentration of surface samples collected at the 3 main RWQCB sampling stations exceed 160 µg/L as described below.

Recycled Water Discharge Control Criteria

Recent monitoring data from the RWQCB for the period from June – December, 2001 yielded a mean chlorophyll a concentration of 97.0±38.8 µg/L, higher than the mean value of 52.4 µg/L for the July, 2000 – July, 2001 period (C. Li, pers. comm.). That is, Lake Elsinore experiences seasonal and year-to-year variations in chlorophyll concentrations (e.g., Fig. 1). As shown in Fig. 1, chlorophyll values have been comparatively low during the spring and early summer months, and increased rather markedly during the late summer and fall period. This was particularly pronounced for 2001, where the average surface (0-2 m) chlorophyll concentration of the 3 RWQCB sampling stations reached 155.0±27.7 µg/L in October, 2001.The mean total P concentration in the lake does not appear to have increased, however (0.105 vs. 0.119 mg/L for the June – December, 2001 and July, 2000 - July, 2001 periods, respectively).

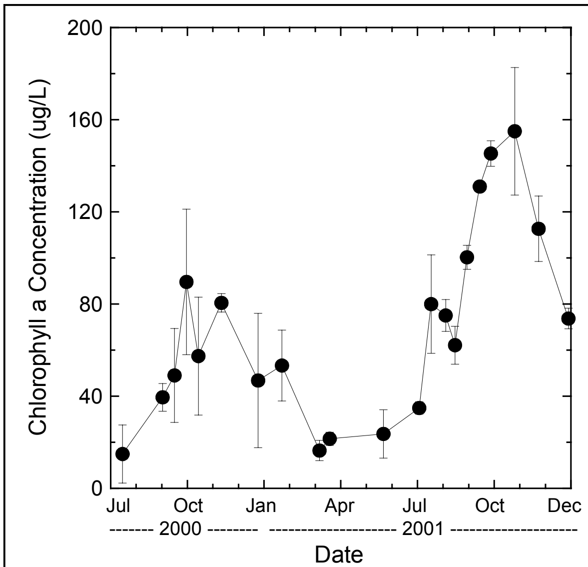

Fig. 1. Average chlorophyll a concentration of the 3 surface stations: July 2000 – December, 2001.

The observed variance in chlorophyll a concentrations in the lake indicates that it is difficult to anticipate the short-term chlorophyll levels in the lake under natural conditions; prediction of the chlorophyll levels during recycled water addition is even more challenging. Nevertheless, it is important to set action levels wherein delivery of recycled water to the lake will be stopped and its impacts evaluated.

Based on recent monitoring data (Fig. 1), the maximum anticipated daily "peak" chlorophyll concentration under current conditions is approximately 160 µg/L. This baseline peak value will be used as the action level for recycled water addition. First of all, additional monitoring of the chlorophyll a levels following schedule A (Table 1) will be initiated should this concentration be exceeded. If the average concentration of chlorophyll a at the 3 primary surface sampling sites (i.e., the RWQCB stations) exceeds the action level of 160 µg/L for 3 consecutive sampling days, then the recycled water addition will be stopped and the program will be evaluated by the Lake Elsinore Monitoring Committee comprised of representatives of the RWQCB, EVMWD, City of Lake Elsinore, and LESJWA.

The recycled water addition may resume when the chlorophyll concentration drops 20% below the action level (i.e., below 130 µg/L) for three consecutive sampling days (schedule A) or by consensus of the representatives of the RWQCB, EVMWD, City of Lake Elsinore, and LESJWA.

The data from Fig. 1 was used to develop a probability distribution function that shows the frequency in which chlorophyll a concentrations fell within given ranges (Fig. 2). Based upon recent monitoring data for the lake, the probability of exceeding the peak value under present conditions is less than 5%, while average chlorophyll a levels exceeded the proposed restart value of 130 µg/L about 15% of the time (Fig. 2). Monitoring of chlorophyll a will return to the previous sampling schedule following the restart of recycled water addition.

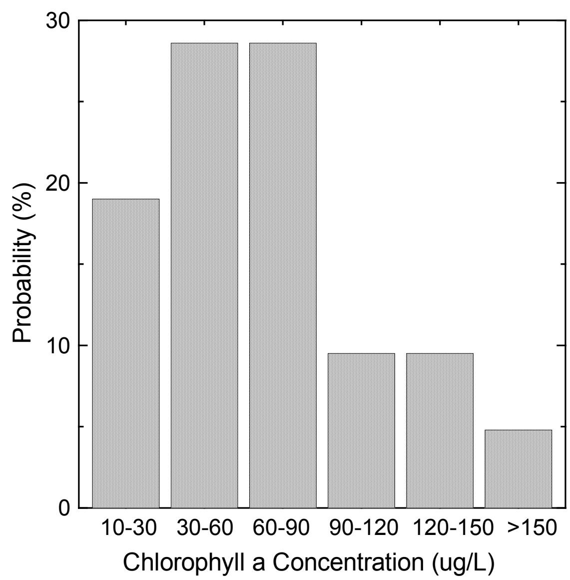

Fig. 2. Probability distribution function for chlorophyll.

Sampling Time

Sampling activities should be completed before 2:00 p.m. to obtain more consistent readings. Typically, strong winds from a westerly direction cause lake mixing and strong waves in the afternoon.

Field Sampling and Laboratory Analyses

The University of California at Riverside (UCR) will conduct the field sampling and laboratory analyses. UCR will submit a QAPP outlining field and laboratory protocol to the RWQCB for approval prior to the initiation of any sampling. Additional assistance from the City of Lake Elsinore, EVMWD or RWQCB staff may be used as needed during the study period.

Data Processing

Monitoring data will be processed using appropriate statistical methods and compared with predicted values (e.g., Anderson, 2001) where appropriate.

Reporting

A report will be submitted after 6 weeks of monitoring summarizing the results of the initial analyses, followed by quarterly reports thereafter. A final report will also be prepared and submitted within 45 days of completion of the monitoring program.

Cost

The total cost of the proposed monitoring program is $ 93,500. The principal expenses are associated with graduate student support (Graduate Student Researcher (GSR) stipend and tuition, fees and health insurance). Costs are summarized in Table 2.

Table 2. Monitoring program costs.

Description	Year 1	Year 2	Total
GSR Salary and Benefits	22,000	24,000	46,000
Lab Assistant Salary and Benefits	5,000	4,000	9,000
Supplies and Expenses	10,000	10,000	20,000
Travel	5,000	5,000	10,000
Total Direct Cost	42,000	43,000	85,000
Indirect Cost (10%)	4,200	4,300	8,500
Total Cost	*46,200*	*47,300*	*93,500*

References

Anderson, M.A. 2001. Internal Loading and Nutrient Cycling in Lake Elsinore. Final Report to the Santa Ana Regional Water Quality Control Board. 52 pp.

APHA. 1989. Fluorometric Determination of Chlorophyll a. 10200 H.3. In *Standard Methods for the Examination of Water and Recycled water. 17th ed.* p. 10-34.

APPENDIX

Predicted Nutrient Plume Associated with Recycled Water Addition to Lake Elsinore

Michael Anderson

A 2-D depth-averaged finite element model was used to simulate the distribution of dissolved phosphorus in Lake Elsinore near the proposed inlet location for recycled water addition. A continuous influent flow of 3.5 MGD or 0.153 m^3/s was discharged through a channel with an assumed cross-section of 0.3 m^2 and a velocity of 0.5 m/s. Weather station records from last spring were used to develop a typical wind field for the lake. Winds were weak (~1 m/s) and out of the north-northeast (~20-30°) during the early morning, and then strengthened to about 6 m/s from the SSW (approximately 210°) during the afternoon (Fig. A1).

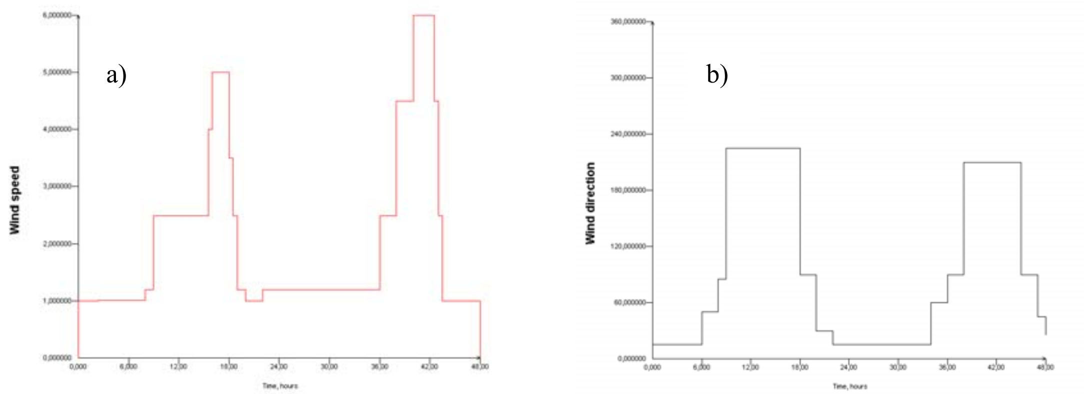

Fig. A1. Wind field showing 2 diural cycles: a) windspeed (m/s) and b) wind direction (N = 0°).

Two diurnal cycles were simulated, the first to eliminate any effects of initial conditions, while the 2nd day was used in the analysis. The influent flow was not predicted to alter the circulation of the lake; even near the discharge point, wind-forcing controlled the lake hydrodynamics (Fig. A2).

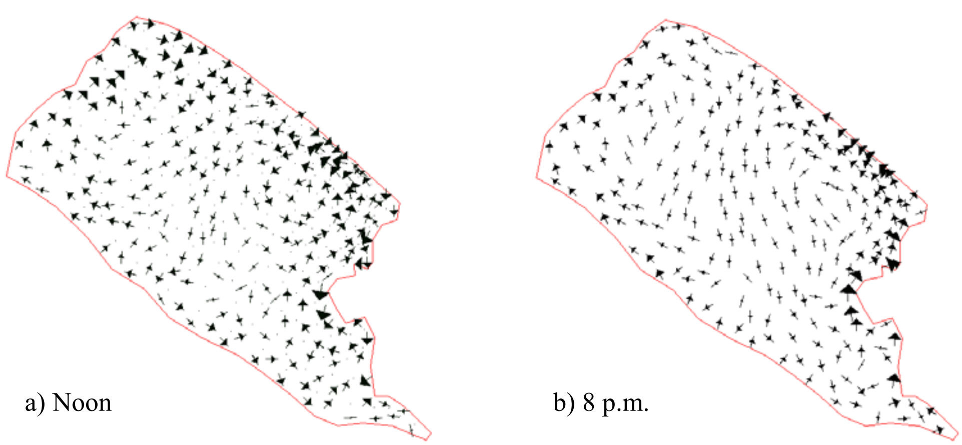

Fig. A2. Predicted circulation pattern in Lake Elsinore at: a) noon and b) 8 p.m.

Assuming the 2-D depth-averaged approximation holds during the well-mixed winter-spring period, a counter-clockwise circulation near the southeast part of the lake (near the discharge point) was predicted with near shore velocities of several cm/s (Fig. A2). This predicted circulation resulted in a nutrient plume that was advected in a northwesterly direction along the shore (Fig. A3). The predicted plume was about 1000 m in lateral extent, with SRP concentrations decreasing from a concentration of about 100 µg/L near the discharge point to about the lake background of 10 µg/L over this distance. The plume was predicted to extend about 400 m perpendicular to the shoreline into the lake.

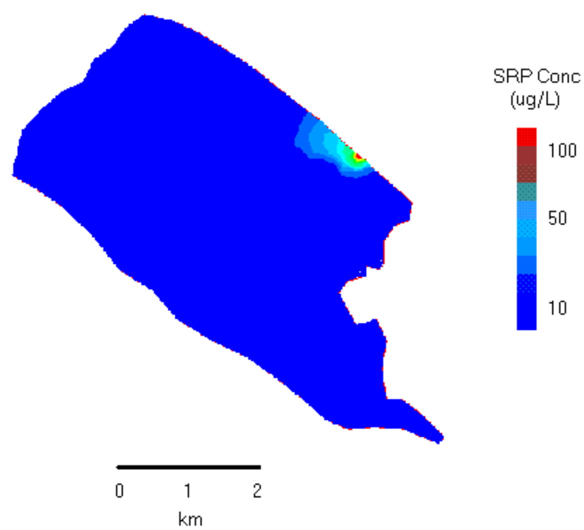

Fig. A3. Predicted typical SRP concentrations near the discharge point.

The predicted circulation and plume distribution was sensitive to the direction of the strong afternoon winds – winds about 40° more westerly than used above (i.e., about 250 °) resulted in a circulation that resulted in the plume being transported southeast of the inlet along the shore. Longer-term simulations (30 days) demonstrated that a measurable SRP plume (defined here as an SRP concentration >20 µg/L) would remain restricted to a lateral distance less than about 1000 m from the inlet point and only about 400 m perpendicular to the shore.

Based upon these simulation results, it appears that 6 – 8 sampling locations near the inlet channel would probably be sufficient to capture the main features of the nutrient plume. Due to the sensitivity of the predicted plume migration to relatively subtle variations in wind direction, a symmetrical sampling scheme around the inlet is recommended, with furthest sampling points approximately 1000 m from the inlet location (Fig. A4, black circles). The 3 red circles represent the approximate locations of the RWQCB water quality sampling stations.

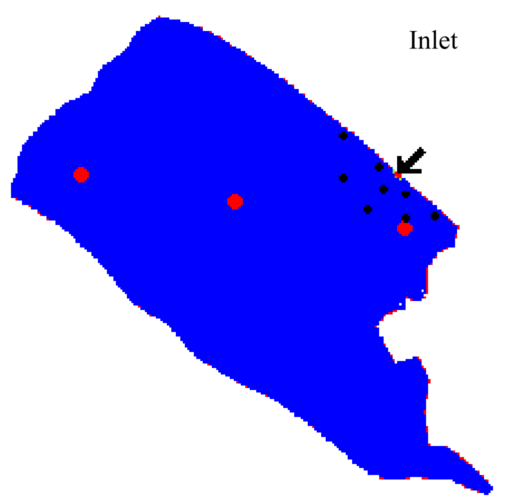

Fig. A4. Proposed lake sampling sites.